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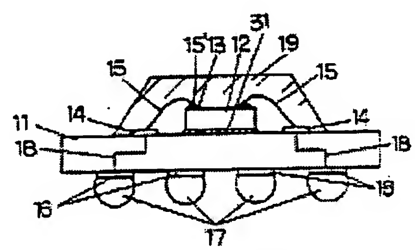
(54) Title of the Invention: Electronic Component and Manufacturing Method Thereof

(57) Abstract

Problem to be solved: To provide an electronic component manufacturing method capable of bonding a gold wire and of soldering favorably on a copper pad on a substrate.

Solution: Nickel films 22 and 25 are formed on copper pads 21 and 24 on a substrate 11, and then gold films 23 and 26 having sufficient thickness for [good] metal bonding performance are formed on the nickel films 22 and 25. In order to inhibit the formation of a gold-tin compound which degrades the reliability of solder, the gold film 26 on an electrode 16 is [partially] removed and made thinner by dry etching. Consequently, the quantity of gold that melts into the solder is suppressed and a solder bump 17 is formed favorably. Also, because the gold film 23 has a sufficient thickness, connection to the semiconductor element by wire bonding or the like can be implemented favorably, thereby enhancing the reliability of the electronic component.

A



11 Substrate
12 Chip
14, 16 Electrode
15 Wire
17 Solder bump

Claims

Claim 1

An electronic component comprising:

a substrate provided with a metal barrier consisting of at least nickel and being formed on a copper surface;

a gold film having a thickness sufficient for [good] metal bonding performance and being formed on said metal barrier;

a semiconductor element mounted on said substrate; and

a means for connecting the semiconductor element and said gold film; wherein

a solder area is provided on an electrode on which said gold film that has been thinned.

Claim 2

A method of manufacturing an electronic component, comprising the steps of:

forming a metal barrier consisting of at least nickel on a copper surface;

forming a gold film having a thickness sufficient for [good] metal bonding performance on said metal barrier;

mounting a semiconductor element on said substrate;

connecting said semiconductor element to said gold film;

sealing said semiconductor element with resin;

dry etching to reduce the thickness of said gold film after resin sealing; and

soldering on an electrode on which said gold film has been thinned.

Detailed Explanation of the Invention

[0001]

Relevant Technical Field of the Invention

The present invention relates to an electrical component and a method of manufacturing an electronic component.

[0002]

Prior Art

A structure in which a wire is bonded onto an electrode on the surface of a substrate in order to connect the substrate and a semiconductor element, and a bump is formed as a protruding electrode on top of another electrode, is a known electronic component assembly structure. The ball grid array (BGA) package is known as such an electronic component. Gold wire is commonly used for the wire, and solder is commonly used for the bump.

[0003]

FIG. 10 is a cross-sectional drawing of a conventional substrate. In the drawing, reference numeral 1 indicates a substrate of glass epoxy or the like, having circuit pattern copper electrodes 2 and 3 formed on its upper and lower surfaces. Nickel films 4 and 5 are formed on the copper electrodes 2 and 3, and gold films 6 and 7 are formed on the nickel films 4 and 5. An internal wire 8 connects the upper copper electrode 2 and lower copper electrode 3. The tip of a gold wire 9 for connecting a chip (not shown) mounted on the substrate 1 is bonded to the top of the gold film 6 of one copper electrode 2, and a solder bump 10 is formed on top of the gold film 7 of the other copper electrode 3, thereby assembling an electronic component.

[0004]

The nickel films 4 and 5 and gold films 6 and 7 are generally formed by plating. The gold films 6 and 7 are formed for the purpose of enhancing the bonding performance of the gold wire 9. Conventionally, the gold films 6 and 7 had a thickness of about 0.2 to 1 micron, which is considerably thick. The nickel films 4 and 5 are formed as a metal barrier to prevent the copper

material of the copper electrodes 2 and 3 from diffusing into the gold films 6 and 7, and forming an oxide film when exposed to air. If an oxide film forms on the surface of the gold film 6, the bonding of gold wire 9 will be unsatisfactory.

[0005]

Problem to be Solved by the Invention

In the above-described conventional method, during the electrolytic gold plating process, the nickel component of the metal barrier nickel films 4 and 5 melts into the plating solution, and the nickel mixes into the gold plating. The portion of the mixed-in nickel positioned on the surface of the gold films 6 forms an oxide film as the result of heating during the process for affixing the chip. This oxide film impairs the bonding of the gold wire 9. Because the amount of nickel on the surface decreases as the gold film becomes thicker, the thickness of gold films 6 and 7 must be greater than a certain thickness in order to prevent the formation of this oxide film to the extent possible.

[0006]

However, increasing the thickness of the gold films 6 and 7 decreases the bonding strength of the solder bump 10. This is because, when forming the solder bump 10, the gold in the gold film 7 melts into the solder bump 10 and combines with tin in the solder to form a brittle compound. Thus, it is preferable that one gold film 6 is thick for the purpose of bonding the gold wire 9 and that the other gold film 7 is thin for the purpose of attaching solder such as forming the solder bump 10. Both of these requirements could not be satisfied at the same time and this contradictory relationship was a problem.

[0007]

Accordingly, it is an object of the present invention to provide an electronic component manufacturing method capable of bonding a gold wire and of attaching solder favorably on copper electrodes on a substrate.

[0008]

Means For Solving the Problem

The electronic component recited in claim 1 comprises a substrate provided with a metal barrier consisting of at least nickel and being formed on a copper surface; a gold film having a thickness sufficient for [good] metal bonding performance and being formed on the metal barrier; a semiconductor element mounted on the substrate; and a means for connecting the semiconductor element and the gold film; wherein a solder area is provided on an electrode on which the gold film that has been thinned.

[0009]

The method of manufacturing an electronic component recited in claim 2 comprises the steps of: forming a metal barrier consisting of at least nickel on a copper surface; forming a gold film having a thickness sufficient for [good] metal bonding performance on the metal barrier; mounting a semiconductor element on the substrate; connecting the semiconductor element to the gold film; sealing the semiconductor element with resin; dry etching to reduce the thickness of the gold film after resin sealing; and soldering on an electrode on which the gold film has been thinned.

[0010]

Embodiment of the Present Invention

According to the present invention having the above-described configuration, after forming a gold film of sufficient thickness for [good] metal bonding performance on an electrode on the substrate, the gold film which impairs bonding performance of solder is removed and thinned by plasma cleaning, and then a solder bump is formed [on the thinned gold film]. Consequently, the gold film and semiconductor element can be connected favorably by wire bonding or the like, and the solder bump can be formed favorably.

[0011]

An embodiment of the present invention is described below with reference to drawings. FIG. 1 is a view of the assembly structure of an electronic component in an embodiment of the present invention; FIGS. 2 and 3 are cross-sectional views of the same substrate; FIG. 4 is a partial cross-sectional view of the same substrate; FIGS. 5 and 6 are cross-sectional views of the same substrate; FIG. 7 is a cross-sectional view of the same[1] dry etching apparatus; and FIGS. 8 and 9 are cross-sectional views of the same substrate.

[0012]

First, the structure of an electronic component A is described. In FIG. 1, reference numeral 11 indicates a substrate onto the top of which a chip 12 is bonded with a thermosetting adhesive 31. An electrode 13 on the surface of the chip 12 and an electrode 14 on the top surface of the substrate are electrically connected by a gold wire 15. Reference number 15' indicates a gold ball formed at a tip of the gold wire, and this gold ball 15' is bonded to the electrode 13.

[0013]

On the bottom surface of the substrate 11, an electrode 16 is formed. A solder bump 17 is formed on the electrode 16. An internal wire 18 connects the electrodes 14 and 16. The top surface of the substrate 11 is provided with molded resin 19 in order to seal the chip 12 and the gold wire 15.

[0014]

Next, a method of manufacturing the electronic component shown in FIG. 1 is described with reference to FIGS. 2 through 8. FIGS. 2 through 8 are shown in the sequence of the manufacturing process. FIG. 2 shows a cross-sectional view of the substrate 11. First, as shown in FIG. 2, an electrode 14 is formed on the upper surface of the substrate 11. The electrode 14 is formed by coating the top of a copper electrode 21 with a nickel film 22 as a metal barrier layer, and then by coating the nickel film 22 with a gold film 23 having a sufficient thickness for [good] metal bonding performance, i.e., having a sufficient thickness (of about 0.2 to 1 micron) so as not to impair bonding with metal. The copper electrode 21 is formed by adhering copper foil to the surface of the substrate 11, and then removing the unnecessary portion by etching. The nickel film 22 and the gold film 23 are formed by plating. Additionally, an electrode 16 is also formed similarly on the lower surface. An electrode 16 is formed by coating a copper electrode 24 with a nickel film 25, and then by forming a gold film 26 on the nickel film 25 in the same manner as for the upper electrode 14.

[0015]

Next, a chip 12, which is a semiconductor element, is mounted on the top surface of the substrate 11. The chip 12 is adhered by a thermosetting adhesive 31 applied in advance on the top surface of the substrate 11. The substrate 11 is then heat-treated. Curing the thermosetting adhesive 31 causes the chip 12 to become affixed to the substrate 11. FIG. 4 is a cross-sectional view of a region in the vicinity of electrodes 14 and 16 on the substrate 11 after this heat treatment has been performed. Here, since gold films 23 and 26 have a thickness sufficient for [good] metal bonding performance, a nickel oxide film that impairs the bonding performance of gold wire does not form on the surface of the gold films 23 and 26.

[0016]

Next, as shown in FIG. 5, a gold wire 15 is bonded onto the gold film 23 of the upper electrode 14 by wire bonding. As a result, the chip 12 is connected to the gold film 23. Thus, the gold wire 15 functions as means for connecting the chip 12 and the gold film 23. At this time, because the surface of the gold film 23 is almost entirely free of the nickel oxide film that

[1] Translator's note: The use of "same" here is unclear. There is no prior reference to a dry etching apparatus.

impairs the bonding performance of gold wire, bonding can be implemented favorably. Later, as shown in FIG. 6, the chip 12 and the gold wire 15 are sealed by molded resin 19.

[0017]

Next, dry etching is performed to thin the gold film at the electrode 16 side. The structure of a dry etching apparatus 40 used in this dry etching is described below with reference to FIG. 7. In FIG. 7, reference numeral 41 indicates an upper casing. The upper casing 41, together with a lower casing 42, form a vacuum container 43 that may be opened and closed. An electrode 44 is disposed at the bottom of the lower casing 42. A high frequency power supply apparatus 45 is connected to the electrode 44. Pipes 46, 47 and 48 are provided at the bottom surface of the lower casing 42. A vacuum source 49 is connected to the pipe 46. Additionally, a gas supply unit 50 that supplies plasma-etching gas such as argon gas is connected to the pipe 47. Furthermore, a vacuum break valve 51 is attached to the pipe 48.

[0018]

An earth electrode 52 is mounted at the top portion of the upper casing 41. The earth electrode 52 is connected to a grounding unit 53 and is installed at a location opposite the electrode 44. The substrate 11 is mounted on the electrode 44.

[0019]

This plasma etching apparatus 40 has a configuration as described above and its operation is described below. With substrate 11 turned upside down so that its electrode 16 side is facing upwards, the substrate 11 is mounted on the electrode 44 as shown in FIG. 7, and then upper casing 41 is closed. Then, the vacuum source 49 initiates a vacuum suction and the inside of the vacuum container 43 reaches a specified degree of vacuum. Next, the gas supply unit 51 supplies argon gas into the vacuum container 43 and the high-frequency power supply apparatus 45 applies a high frequency voltage to the electrode 44. The argon gas inside the vacuum container 43 forms an argon ion plasma that collides with the top surface of the substrate 11 mounted on the electrode 44 as indicated by the broken-line arrow in FIG. 7 to accomplish the etching. In this manner, the gold film 26 on the surface of the electrode 16 removed, and the gold film 26 is thinned to a thickness of approximately 0.01 to 0.2 micron. In order to ensure good wettability between the molten solder and the electrode 16, the gold film 26 is not completely removed.

[0020]

Next, as shown in FIG. 8, a solder ball 17 is mounted on the gold film 26 on the electrode 16 side. At this time, flux 20 is applied between the solder ball 17 and the gold film 26. Then, the substrate 11 is sent to a reflow process, the solder ball 17 is soldered to the electrode 16 surface, and the soldered area becomes a solder bump 17, thereby completing the electronic component A shown in FIG. 1. At this time, the gold film 26 melts into the solder bump 17, but because the gold film 26 was made thin by dry etching, the quantity of gold that melts into the solder bump 17 is extremely small. Therefore, the gold-tin compound that degrades bonding performance of the solder bump 17 is formed in a very small quantity only, enabling the formation of a highly reliable solder bump 17. Moreover, since the surface of the gold film 26 is processed by etching, nickel contaminants and the like that impair solder wettability are thoroughly removed. Thus, solder can be bonded to the electrode with sufficient wettability.

[0021]

The present invention is not limited to the above-described embodiment. In the above-described embodiment, a semiconductor element is connected to the gold film 23 of the electrode 14 by wire bonding, but the connection method is not limited to wire bonding, and ribbon bonding, TAB bonding, flip semiconductor element bonding and the like may also be used.

[0022]

In the above-described embodiment, a semiconductor element is mounted on one side of the substrate 11 and a solder bump is formed on the other side, but the bonding and soldering may be mixed within the same substrate. For example, as shown in FIG. 9(a), a semiconductor element 42 may be mounted on a substrate 41 and connected to an electrode on the substrate 41 by wire bonding, and an electronic component 45 may be mounted and soldered onto a gold film on an electrode 44 formed on this same [substrate] surface after the gold film has been thinned. Additionally, as shown in FIG. 9(b), a semiconductor element 48 may be connected to an electrode 47 on a substrate 46 by wire bonding, and a solder bump 50 may be formed on a gold film on an electrode 49 formed on the same [substrate] surface after the gold film has been thinned.

[0023]

Effect of the Invention

In the present invention, after forming a gold film having sufficient thickness for [good] metal bonding performance on an electrode on a substrate and then performing dry etching to remove and thin the gold film that impairs bonding performance of the solder, a solder bump or the like is soldered. Thus, bonding can be favorably implemented without any formation of the nickel oxide film that impairs wire bonding or other types of connections between the gold film and semiconductor element, and soldering can be favorably implemented without generating a brittle tin-gold compound, thereby enabling a highly reliable electronic component to be obtained.

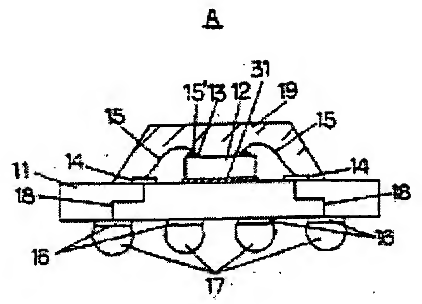
Brief Explanation of the Drawings

FIG. 1 is a view of the assembly structure an electronic component in an embodiment of the present invention.
FIG. 2 is a cross-sectional view of a substrate in an embodiment of the present invention.
FIG. 3 is a cross-sectional view of a substrate in an embodiment of the present invention.
FIG. 4 is a partial cross-sectional view of a substrate in an embodiment of the present invention.
FIG. 5 is a cross-sectional view of a substrate in an embodiment of the present invention.
FIG. 6 is a cross-sectional view of a substrate in an embodiment of the present invention.
FIG. 7 is a cross-sectional view of a dry etching apparatus in an embodiment of the present invention.
FIG. 8 is a cross-sectional view of a substrate in an embodiment of the present invention.
FIG. 9 is a cross-sectional view of a substrate in an embodiment of the present invention.
FIG. 10 is a cross-sectional view of a conventional substrate.

Explanation of the Reference Numerals

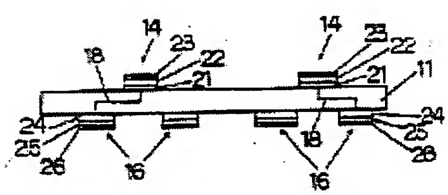
11 Substrate
12 Chip
14, 16 Electrode
15 Wire
17 Solder bump
23, 26 Gold film

FIG. 1



11 Substrate
12 Chip
14, 16 Electrode
15 Wire
17 Solder bump

FIG. 2



23, 26 Gold film

FIG. 3

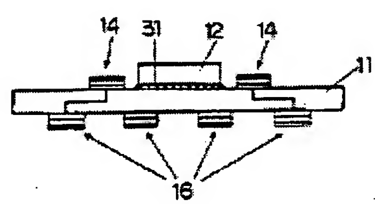


FIG. 4

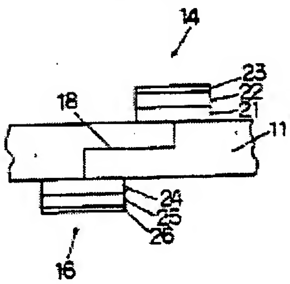


FIG. 5

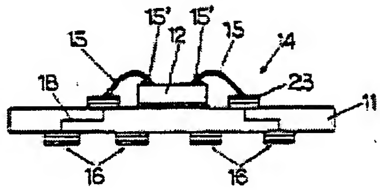


FIG. 6

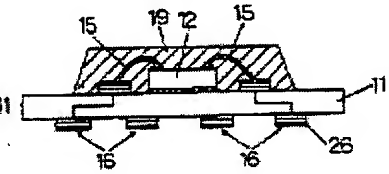


FIG. 7

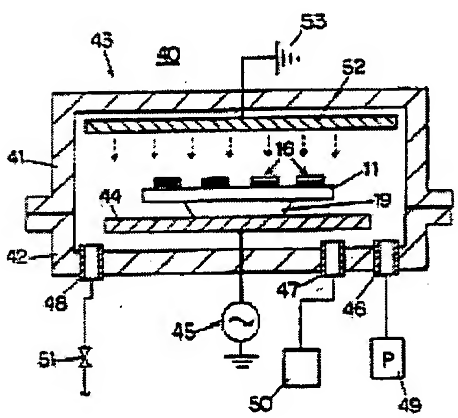


FIG. 8

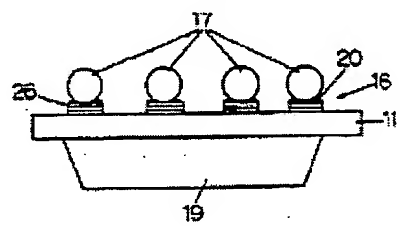


FIG. 9

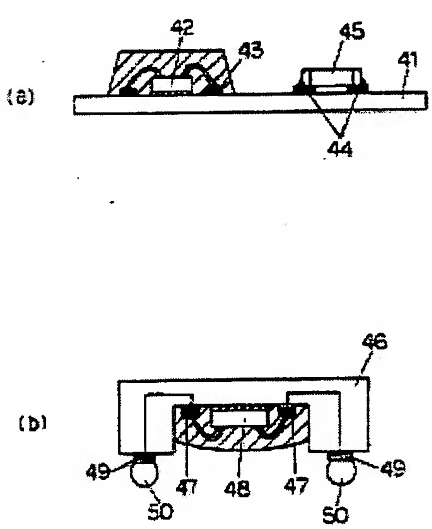


FIG. 10